[Name of Document] Specification

[Title of the Invention] METHOD OF TRANSFERRING DEVICE, METHOD OF PRODUCING DEVICE HOLDING SUBSTRATE, AND DEVICE HOLDING SUBSTRATE

[What is Claimed is]

[Claim 1] A method of transferring device comprising the steps of:

irradiating an interface between a first substrate and a device provided on said first substrate with an energy beam selectively and transmitting through said first substrate to selectively release said device,

transferring said selectively released device onto a device holding layer provided on a device holding substrate, and

transferring said device transferred to said device holding layer onto a second substrate.

[Claim 2] The method of transferring device as set forth in claim 1, further comprising a step of cleaning said device on said device holding layer in the condition where said device is transferred onto said device holding layer.

[Claim 3] The method of transferring device as set forth in claim 1, wherein an adhesive layer is preliminarily provided on said second substrate, and said

adhesive layer is irradiated with an energy beam when said device transferred onto said device holding layer is transferred onto said second substrate.

[Claim 4] The method of transferring device as set forth in claim 1, wherein said device is formed of a material which produces ablation upon irradiation with said energy beam, and ablation is generated by said selective irradiation with said energy beam to cause exfoliation at said interface between said device and said first substrate.

[Claim 5] The method of transferring device as set forth in claim 4, wherein said device is constituted of a nitride semiconductor material.

[Claim 6] The method of transferring device as set forth in claim 5, wherein said nitride semiconductor material is a GaN-based material.

[Claim 7] The method of transferring device as set forth in claim 1, wherein said first substrate is a sapphire substrate.

[Claim 8] The method of transferring device as set forth in claim 1, wherein said device has a structure having a pointed head portion or a flat plate-shaped structure.

[Claim 9] The method of transferring device as set forth

forth in claim 1, wherein said device is a light-emitting device.

[Claim 10] The method of transferring device as set forth in claim 1, wherein said device has a structure having a pointed head portion, and said device holding layer is provided at its surface with a recessed portion shaped for fitting of said pointed head portion.

[Claim 11] The method of transferring device as set forth in claim 1, wherein said device holding layer is constituted of a silicone resin layer.

[Claim 12] A method of producing device holding substrate wherein a substrate provided with a device having a pointed head portion is prepared, an uncured silicone resin layer is provided on a device holding substrate, then said substrate provided with said device having said pointed head portion is adhered to said device holding substrate, and said silicone resin layer is provided at its surface with a recessed portion shaped for fitting of said pointed head portion.

[Claim 13] The method of producing device holding substrate as set forth in claim 12, wherein said device is coated with a release agent before said substrate provided with said device having said pointed head portion is adhered to said device holding substrate.

[Claim 14] A device holding substrate comprising a substrate, and a silicone resin layer provided on said substrate, wherein said silicone resin layer is provided at its surface with a recessed portion shaped for fitting of a pointed head portion of a device to be held.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention relates to a method of transferring device for selectively releasing a minutely processed device and transferring the device onto another substrate, a method of producing a device holding substrate, and a device holding substrate.

[0002]

[Prior Art]

Hitherto, in the case of assembling an image display device by arranging light-emitting devices in a matrix, either the devices are provided on a substrate as in liquid crystal display devices (LCD) or plasma display panels (PDP), or singular light-emitting diode (LED) packages are arranged as in light-emitting diode displays (LED displays). In an image display device such as LCD and PDP according to the prior art, separation of the

devices is impossible, with respect to the pitch of the devices or pixels and the production process thereof, and the devices are ordinarily spaced from each other by the pixel pitch of the image display device from the beginning of the production process.

[0003]

Not limited to the light-emitting devices, there has been a technology of once providing semiconductor thin film devices or semiconductor devices in high density on a substrate and thereafter transferring the devices onto another substrate. For example, in a method of transferring a thin film device disclosed in Japanese Patent Laid-open No. Hei 11-26733, a substrate used at the time of producing thin-film devices as liquid crystal control devices is different from a substrate used at the time of mounting the product, and the thin-film devices are transferred onto the substrate used at the time of mounting. As another transfer technique, there has been known, for example, the transferring method disclosed in Japanese Patent Laid-open No. Hei 7-254690, in which a film capable of generating minute bubbles is provided at the boundary portion between a substrate and a device portion (semiconductor plate), and is irradiated with a laser beam to generate minute bubbles, whereby the device

portion (semiconductor plate) is transferred to the side of a support. Further, according to a technique disclosed in Japanese Patent Laid-open No. Hei 11-142878, thin-film transistors constituting a liquid crystal display portion on a first substrate are entirely transferred onto a second substrate, and then selectively transferred from the second substrate onto a third substrate corresponding to the pixel pitch.

[0004]

[Problems to be Solved by the Invention]

However, the transfer techniques as mentioned above have the following problems. First, in the method of transferring a thin-film device disclosed in Japanese Patent Laid-open No. Hei 11-26733, a thermo-melting adhesive layer of a second separation layer undergoes generation of ablation upon irradiation with laser light, attended by generation of gas or the like, so that the treatment of the gas or the like is a problem on a process basis. In addition, the thermo-melting adhesive layer itself is left upon transfer of the device onto a secondary transfer body, so that removal thereof by use of xylene or the like is needed. In order to adhere the device to the secondary transfer body by curing an epoxy resin as the adhesive layer, a long curing time for

curing of the epoxy resin is needed. Further, in order to release the thin-film devices such as thin-film transistors from the entire substrate, amorphous silicon must be preliminarily provided on the whole surface of the substrate, and the whole surface of the substrate must be irradiated with laser light.

[0005]

In the transferring method disclosed in Japanese Patent Laid-open No. Hei 7-254690, laser is transmitted through the support body, so that the support body is limited to those transparent to laser light. In addition, it is described in the publication that sufficient binding energy is provided between the semiconductor plate and the support body and adhesion to the support body is achieved, but absorption of laser light occurs between the semiconductor plate and the support body, so that bubbles may be generated by ablation to break the semiconductor devices, resulting in a decrease of yield.

[0006]

In the technique disclosed in Japanese Patent Laid-open No. Hei 11-142878, the portions of the thin-film transistor devices as the object of transfer are selectively irradiated with UV light, to lower the adhesive power of a UV release resin provided between the

thin-film transistors and the substrate from which the transistors are to be transferred. However, it takes time for the adhesive power of the UV release resin to be lowered by irradiation with UV light, leading to a lowering of throughput on a process basis. In addition, when sufficient lowering of the adhesive power is not obtained, yield of transfer is also lowered.

[0007]

Accordingly, it is an object of the present invention to provide a method of transferring device, a method of producing a device holding substrate, and a device holding substrate which enable minutely processed devices to be transferred in a short time without inducing an increase in the number of steps and without lowering of the yield of transfer.

[0008]

[Means for Solving the Problems]

In order to solve the above-mentioned problems, a method of transferring device according to the present invention is characterized by including the steps of irradiating an interface between a first substrate and a device provided on the first substrate with an energy beam selectively and transmitting through the first substrate to selectively release the device, transferring

the device selectively released onto a device holding layer provided on a device holding substrate, and transferring the device transferred onto the device holding layer onto a second substrate.

[0009]

In the method of transferring device as above, the energy beam for releasing the device is used for selective irradiation of the interface between the device and the first substrate, the energy is not fed to needless portions, and the release at the interface between the device and the substrate is carried out in a short time. In addition, since the interface between the device and the substrate is not specially formed but is formed spontaneously in the process of forming the device, the increase in the number of steps for the purpose of release can be minimized.

[0010]

In the present invention, as the device, especially, one constituted of a material generating ablation upon irradiation with an energy beam can be used, for example, a semiconductor light-emitting device or the like constituted of a nitride semiconductor material can be used. The semiconductor light-emitting device constituted of a nitride semiconductor material can be produced by

crystal growth on a sapphire substrate, and the sapphire substrate transmits a desired energy beam, so that the energy beam for generating release can be directed to the interface between the sapphire substrate and the semiconductor light-emitting device.

[0011]

In addition, a method of producing a device holding substrate according to the present invention is characterized in that a substrate provided with a device having a pointed head portion is prepared, an uncured silicone resin layer is provided on a device holding substrate, then the substrate provided with the device having the pointed head portion is adhered to the device holding substrate, and the silicone resin layer is provided at its surface with a recessed portion shaped for fitting of the pointed head portion.

[0012]

Since the silicone resin layer is provided at its surface with a recessed portion shaped for fitting of the pointed head portion of the device, the device having the pointed head portion can be securely held without positional stagger or the like. Further, the silicone resin layer has a surface which itself has a sticky property, so that the device can be securely held through

fitting of the pointed head portion and the recessed portion.

[0013]

[Mode for Carrying out the Invention]

Now, embodiments of the present invention will be described in detail below referring to the drawings. In the following, First Embodiment is an example of a method of selectively transferring a flat plate shaped light-emitting diode, Second Embodiment is an example of a method of selectively transferring a light-emitting diode having a pointed head portion, and Third Embodiment is an example of a method of producing a device holding substrate using a silicone resin layer.

[0014]

[First Embodiment]

The method of transferring device according to the present embodiment will be described referring to FIGS. 1 to 5. First, as shown in FIG. 1, a plurality of light-emitting diodes 12 are provided in a matrix arrangement on a sapphire substrate 10 which is a light-transmitting first substrate. The light-emitting diode 12 is a device composed of a nitride semiconductor material such as gallium nitride, and, as one example, has a double hetero structure in which an active layer is sandwiched between

clad layers. The light-emitting diode 12 is formed by layering a gallium nitride crystal layer or the like through selective growth on the sapphire substrate 10, and, in the stage of FIG. 1, a desired light-emitting region is already formed but final wiring is not yet provided. The light-emitting diodes 12 arranged in a matrix form are disposed on the sapphire substrate 10 in the state of being individually separated. They can be individually separated by, for example, RIE (reactive ion etching) or the like. The light-emitting diode 12 is substantially flat plate shaped, and the active layer and the clad layers of the light-emitting diode 12 are extended in parallel with the major surface of the sapphire substrate 10.

[0015]

A device holding substrate 14 for temporarily holding the light-emitting diodes 12 is prepared, and a device holding layer 13 is provided on a surface of the device holding substrate 14 faced to the sapphire substrate 10. The device holding substrate 14 is a substrate having a desired stiffness, and may be one of various substrates such as a semiconductor substrate, a quartz glass substrate, a glass substrate, a plastic substrate and a metallic substrate. The device holding

substrate 14 need not especially transmit light such as laser light, so that it need not be formed of a light-transmitting material. The device holding layer 13 is an adhesive layer temporarily adhered to the surface of the light-emitting diodes 12 to hold the light-emitting diodes 12. The device holding layer 13 may be formed of a thermoplastic resin or a thermosetting resin, and is preferably formed of a silicone resin. The silicone resin does not suffer ablation even when irradiated with excimer laser or YAG laser light, and only the devices can be released, so that yield can be enhanced.

[0016]

The device holding substrate 14 provided thereon with the device holding layer 13 is faced to the major surface of the sapphire substrate 10, and a plurality of light-emitting diodes 12 are press adhered to the surface of the device holding layer 13 at a desired pressure. Next, as shown in FIG. 1, selective irradiation with laser light 15 of excimer laser, YAG laser or the like is carried out, to cause laser ablation at the interface between the light-emitting diodes 12 as objects of selection and the sapphire substrate 10. The laser ablation means a phenomenon in which a fixed material having absorbed the irradiation light is photochemically

or thermally excited, bonds of atoms or molecules at the surface or inside of the excited material are broken and the atoms or molecules are discharged; primarily, it appears as a phenomenon in which the whole or a part of the fixed material undergoes a phase change such as melting, evaporation and gasification. By the laser ablation, the GaN-based material is decomposed into metallic Ga and nitrogen and a gas is generated, between the light-emitting diodes as objects of selection and the sapphire substrate 10. Therefore, the light-emitting diodes 12 can be released comparatively easily. As the laser light 15 for irradiation, particularly, excimer laser is preferably used in view of high output in short wavelength regions, and instantaneous processing is thereby possible. The light-emitting diodes 12 as objects of selection are selectively irradiated with the laser light 15. For the selective irradiation, a mask having desired opening portions may be used, and scanning with controlled irradiation and non-irradiation may also be used.

[0017]

FIG. 2 shows the condition where the light-emitting diodes 12 are selectively released by the laser ablation, in which the light-emitting diodes 12 as objects of

selection are adhered to the surface 13a of the device holding layer 13, and are held on the side of the device holding substrate 14.

[0018]

Next, as shown in FIG. 3, the device holding substrate 14 with the light-emitting diodes 12 held thereto is immersed in a cleaning liquid 16f in a cleaning tank 16, and metal or the like remaining on the surface from which the light-emitting diodes 12 are released by the laser ablation is removed by cleaning. The metal or the like is constituted mainly of metallic Ga formed upon evaporation of nitrogen by the laser ablation. As the cleaning liquid 16f, both alkaline and acid etching liquids may be used. In this step also, where a silicone resin is used as the device holding layer 13, cleaning can be conducted with the light-emitting diodes 12 adhered to the surface 13a of the device holding layer 13; in addition, since the silicone resin is resistant to alkalis and acids, it is not eroded and can hold the light-emitting diodes 12.

[0019]

After the cleaning of the light-emitting diodes 12, as shown in FIG. 4, a second substrate 18 provided with an adhesive layer 19 on its major surface is prepared.

The second substrate 18 is formed of a light-transmitting material such as quartz glass, and the adhesive layer 19 may be formed of a UV-curable adhesive, a thermosetting adhesive, a thermoplastic adhesive or the like. The second substrate 18 provided with the adhesive layer 19 on its major surface is mated with the device holding substrate 14 with the light-emitting diodes 12 held thereon, and irradiation with energy light 17 is conducted, whereby the light-emitting diodes 12 on the device holding substrate 14 are transferred onto the second substrate 18. Where the adhesive layer 19 is formed of a UV-curable adhesive, the adhesive layer 19 can be cured by irradiating the adhesive layer 19 with UV light as the energy light 17, an uncured region 19y of the adhesive layer 19 is brought into contact with the light-emitting diodes 12, and then irradiation with UV light is conducted, whereby the light-emitting diodes 12 can be securely adhered. Where the adhesive layer 19 is formed of a thermosetting adhesive or a thermoplastic adhesive, irradiation with infrared laser light is conducted, whereby adhesion can be achieved through curing or re-melting. Adhesion of the light-emitting diodes 12 may be achieved by curing or re-melting only the regions corresponding to the light-emitting diodes 12,

or, alternatively, adhesion of the light-emitting diodes 12 may be achieved by curing or re-melting the entire surface of the adhesive layer 19. Particularly where a silicone resin is used as the device holding layer 13, even when the adhesive layer 19 and the device holding layer 13 make contact with each other, the excellent release property of the silicone resin ensures easy release of the device holding substrate 14.

[0020]

Finally, as shown in FIG. 5, the device holding substrate 14 is removed together with the device holding layer 13, to yield the second substrate 18 onto which the light-emitting diodes 12 have been selectively transferred.

[0021]

In the method of transferring device as described above, the energy beam for release of the device is caused to selectively irradiate the interface between the device and the first substrate, so that release at the interface between the device and the substrate by laser ablation is achieved in a short time, and the device and the like are not damaged. The interface between the device and the substrate is not specially formed, but is formed spontaneously in the process of forming the device,

so that formation of a release thin film for the purpose of release is needless, and an increase in the number of steps can be minimized. The light-emitting diodes 12 are flat plate shaped, are securely adhered to the device holding layer 13 formed of, for example, a silicone resin or the like, and are transferred without positional stagger. Therefore, an image display device or the like can be produced while restraining a lowering in the yield of production.

[0022]

[Second Embodiment]

About the method of transferring device according to the present embodiment, first, the structure of a light-emitting device as an example of the device used in the present embodiment is shown in FIG. 6. The light-emitting device has a device structure having a pointed head portion. FIG. 6(a) is a sectional view of the device, and FIG. 6(b) is a plan view of the same. The light-emitting device is a GaN-based light-emitting diode, and a device formed by crystal growth on, for example, a sapphire substrate. In such a GaN-based light-emitting diode, irradiation with laser which is transmitted through the substrate causes laser ablation, whereby film exfoliation is generated at the interface between the

sapphire substrate and the GaN-based growth layer attendant on the phenomenon of gasification of nitrogen of GaN, and device separation can be easily achieved.

[0023]

First, as for the structure, a hexagon pyramid shaped GaN layer 32 is selectively grown on a ground growth layer 31 constituted of a GaN-based semiconductor layer. An insulating layer not shown is present on the ground growth layer 31, and the hexagon pyramid shaped GaN layer 32 is formed at a portion where the insulating film is opened, by MOCVD method or the like. The GaN layer 32 is a pyramid shaped growth layer covered with S planes (1-101 planes) where the major surface of the sapphire substrate used at the time of growth is made to be C plane, and is a region doped with silicon. The portions of the inclined S planes of the GaN layer 32 function as clads of a double hetero structure. An InGaN layer 33 as an active layer is formed so as to cover the inclined S planes of the GaN layer 32, and a magnesium-doped GaN layer 34 is formed on the outside thereof. The magnesium-doped GaN layer 34 also functions as a clad.

[0024]

The light-emitting diode is provided with a p electrode 35 and an n electrode 36. The p electrode 35 is

formed on the magnesium-doped GaN layer 34 by vapor deposition of a metallic material such as Ni/Pt/Au or Ni(Pd)/Pt/Au. The n electrode 36 is formed at the portion where the insulating film not shown is opened as above, by vapor deposition of a metallic material such as Ti/Al/Pt/Au. Where the n electrode is taken out from the back side of the ground growth layer 31, formation of the n electrode 36 is needless on the face side of the ground growth layer 31.

[0025]

The GaN-based light-emitting diode with such a structure is a device capable of blue light emission and provided with a hexagon pyramid shaped pointed head portion, and can be released from the sapphire substrate comparatively easily by laser ablation, so that selective release can be realized by selective irradiation with a laser beam. The GaN-based light-emitting diode may have a structure comprising an active layer in a flat plate shape or band shape, and may be an angular pyramid structure having a C plane at a top end portion thereof. Other nitride-based light-emitting devices and compound semiconductor devices may also be applied.

[0026]

Now, description will be made referring to FIGS. 7

to 11. As shown in FIG. 7, a plurality of light-emitting diodes 42 each having a hexagon pyramid shaped pointed head portion 42a are formed in a matrix arrangement on a sapphire substrate 40 which is a light-transmitting first substrate. The light-emitting diode 42 is a device composed of a nitride semiconductor material such as gallium nitride, and, as an example, has a double hetero structure comprising an active layer sandwiched between clad layers. The light-emitting diode 42 is formed by laminating a gallium nitride crystal layer or the like by selective growth or the like on the sapphire substrate 40 having a major surface as C plane. It is to be noted that in the stage of FIG. 7, a desired light-emitting region has been formed but final wiring is not yet applied. The light-emitting diodes 42 in the matrix arrangement are disposed on the sapphire substrate 40 in the state of being separated individually. The individual separation of the devices can be achieved, for example, by RIE (reactive ion etching) or the like. The active layer and the clad layers of the light-emitting diode 42 are extended in parallel to the slant surfaces of the pointed head portion 42a.

[0027]

A device holding substrate 44 for temporarily

holding the light-emitting diodes 42 is prepared, and the device holding substrate 44 is provided with a silicone resin layer 43 on its surface faced to the sapphire substrate 40. The device holding substrate 44 is a substrate having a desired stiffness, and may be one of various substrates such as a quartz glass substrate, a glass substrate, a plastic substrate, and a metallic substrate. The device holding substrate 44 need not specially transmit laser light or the like, and need not be formed of a light-transmitting material. The silicone resin layer 43 is an adhesive layer for temporarily adhering to the surface of the light-emitting diodes 42 and holding the light-emitting diodes 42. The surface of the silicone resin layer 43 is provided with a plurality of recessed portions 43b at the positions of the light-emitting diodes 42, each of the recessed portions 43b has a shape of female die where the pointed head portion 42a of the light-emitting diode 42 has a shape of male die, so that the pointed head portion 42a is just fitted to the recessed portion 43b. Particularly, a silicone resin can be used for forming the device holding layer, whereby ablation is not generated upon irradiation with excimer laser or YAG laser light, only the devices can be released, and yield of production can be enhanced.

[0028]

The device holding substrate 44 provided with the silicone resin layer 43 on its surface is faced to the major surface of the sapphire substrate 40, and the plurality of light-emitting diodes 42 are press adhered to the surface of the silicone resin layer 43 at a desired pressure. Next, as shown in FIG. 7, selective irradiation with laser light 45 of excimer laser or YAG laser is conducted, to cause laser ablation at the interface between the light-emitting diodes 42 as objects of selection and the sapphire substrate 40. By the laser ablation, the GaN-based material is decomposed into metallic Ga and nitrogen, with the result of generation of a gas, between the light-emitting diodes 42 as objects of selection and the sapphire substrate 40, whereby the light-emitting diodes 42 can be released comparatively easily. As the laser light 45 for irradiation, excimer laser is preferably used particularly in view of high output in short wavelength regions, whereby instantaneous processing can be achieved. The laser light 45 is caused to selectively irradiate the light-emitting diodes 42 as objects of selection. For the selective irradiation, a mask having desired opening portions may be used, and scanning with controlled irradiation and non-irradiation

may also be used.

[0029]

FIG. 8 shows the condition where the light-emitting diodes 42 are selectively released by the laser ablation. The pointed head portions 42a of the light-emitting diodes 42 as objects of selection are fitted into the recessed portions 43b provided at the surface of the silicone resin layer 43, and the light-emitting diodes 42 are securely held on the side of the device holding substrate 44. If the recessed portions 43b are not provided and it is tried to hold the light-emitting diodes 42 having the pointed head portions 42a by a flat surface, there would arise the problem that the pointed head portions 42a fall down and accurate positioning is not achieved. When the recessed portions 43b are provided as in the present embodiment, the light-emitting diodes 42 are securely held.

[0030]

Next, as shown in FIG. 9, the device holding substrate 44 with the light-emitting diodes 42 held thereon is immersed in a cleaning liquid 46f in a cleaning tank 46, whereby a metal or the like remaining on the surface from which the light-emitting diodes 42 have been released by laser ablation is removed through

cleaning. The metal or the like is constituted mainly of metallic Ga produced through evaporation of nitrogen by laser ablation. As the cleaning liquid 46f, alkali-based and acid-based etching liquids may both be used. In this step, also, where a silicone resin is particularly used as the silicone resin layer 43, the cleaning can be carried out with the light-emitting diodes 42 adhered to the surface 43a of the silicone resin layer 43. In addition, since the silicone resin is resistant to alkalis and acids, it is not eroded, and can hold the light-emitting diodes 42 as they are.

[0031]

After the cleaning of the light-emitting diodes 42, as shown in FIG. 10, a second substrate 48 provided with an adhesive layer 49 on its major surface is prepared. The second substrate 48 is constituted of a light-transmitting material such as quartz glass, and the adhesive layer 49 is formed by use of a UV-curable adhesive, a thermosetting adhesive, a thermoplastic adhesive or the like. The second substrate 48 provided with the adhesive layer 49 on its major surface is mated with the device holding substrate 44 with the light-emitting diodes 42 held thereon, and irradiation with energy light 47 is conducted, whereby the light-emitting

diodes 42 on the device holding substrate 44 are transferred onto the second substrate 48. Where the adhesive layer 49 is formed of a UV-curable adhesive, irradiation with UV light as the energy light 47 can cure the adhesive layer 49. Therefore, by bringing uncured regions 49y of the adhesive layer 49 into contact with the light-emitting diodes 49 and then irradiating with UV light, the light-emitting diodes 42 can be securely adhered. Where the adhesive layer 49 is formed of a thermosetting adhesive or a thermoplastic adhesive, irradiation with infrared laser light causes adhesion through setting or re-melting. The adhesion of the light-emitting diodes 42 may be conducted through setting or re-melting of only the regions corresponding to the light-emitting diodes 42, and the adhesion of the light-emitting diodes 42 may also be conducted through setting or re-melting of the entire surface of the adhesive layer 49. Because the silicone resin layer 43 is formed as the device holding layer, even if the adhesive layer 49 and the silicone resin layer 43 make contact with each other, the excellent release property of the silicone resin ensures that the device holding substrate 44 can be easily released.

[0032]

Finally, as shown in FIG. 5, the device holding substrate 44 is removed together with the silicone resin layer 43 provided with the recessed portions 43b, to yield the second substrate 48 onto which the light-emitting diodes 42 have been selectively transferred.

[0033]

In the method of transferring device as described above, the energy beam for release of devices is caused to irradiate the interface between the devices and the first substrate, so that the release at the interface between the devices and the substrate is achieved in a short time by laser ablation, and the devices or the like are not damaged. Since the interface between the devices and the substrate is not specially formed but is formed spontaneously in the process of forming the devices, a release thin film for the purpose of release is not needed, so that an increase in the number of steps can be minimized. In addition, since the light-emitting diodes 42 each have a structure having the pointed head portion 42a and the silicone resin layer 4 as the device holding layer is provided with the recessed portions 43b for fitting with the pointed head portions 42a, the light-emitting diodes 42 are securely adhered to the silicone resin layer 43, and are transferred without positional

stagger. Therefore, an image display device or the like can be produced while restraining the lowering of yield of production.

[0034]

[Third Embodiment]

The present embodiment is an embodiment of a device holding substrate provided with a silicone resin layer having recessed portions, and the method of producing the same. The producing method will be described referring to FIGS. 12 to 14.

[0035]

First, as shown in FIG. 12, a plurality of light-emitting diodes 52 each having a hexagon pyramid shaped pointed head portion 52a are formed on a sapphire substrate 50 in a matrix arrangement. The light-emitting diode 52 has the same constitution as the light-emitting diode shown in FIG. 6, and is a device constituted of a nitride semiconductor material such as gallium nitride. The light-emitting diodes 52 in the matrix arrangement are disposed on the sapphire substrate 50 in the state of being individually separated. A release layer 53 is provided on the light-emitting diodes 52. As the release layer 53, a layer of a material such as Teflon and silicone is used, or other mold release agents may also

be used. In order not to damage the shape of the devices, the viscosity of the material of the release layer 53 is set to be low. Control for obtaining such a low viscosity can be conducted by use of a solvent such as xylene.

[0036]

After the release layer 53 covering the light-emitting diodes 52 is cured, as shown in FIG. 13, a device holding substrate 55 is faced to the sapphire substrate 50, and a silicone resin is injected so as not to generate voids between the device holding substrate 55 and the sapphire substrate 50. Then, the silicone resin flows into the spaces between the pointed head portions 52a of the light-emitting diodes 52 provided thereon with the release layer 53, and is cured while reflecting the shape of the pointed head portions 52a of the light-emitting diodes 52. By the curing of the silicone resin, a silicone resin layer 54 provided at its surface with recessed portions 54b shaped for fitting of the pointed head portions 52a is formed on the device holding substrate 55.

[0037]

Subsequently, the light-emitting diodes 52 used as molds are removed together with the sapphire substrate 50, whereby, as shown in FIG. 14, the device holding

substrate 55 provided with the silicone resin layer 54 provided at its surface with the recessed portions 54b shaped for fitting of the pointed head portions 52a is completed. The sapphire substrate 50 can be easily released because the release layer 53 is formed on the light-emitting diodes 52.

[0038]

By use of the device holding substrate 55 provided with the silicone resin layer 54 having the recessed portions 54b for fitting of the pointed head portions 52a, although the light-emitting diodes 52 are transferred with the side of the pointed head portions 52a held, the pointed head portions 52a and the recessed portions 54b are securely fitted to each other, and transfer without positional stagger is realized. The silicone resin layer has the advantage of not generating laser ablation or the like, and can be easily handled in view of its resistance to alkalis and acids in relation to the cleaning liquid.

[0039]

[Fourth Embodiment]

The method of transferring device according to the present embodiment will be described referring to FIGS. 15 to 19. The present embodiment is an example of transfer of a thin film transistor device used in a

liquid crystal display device. First, as shown in FIG. 15, a plurality of thin film transistor (TFT) devices 62 are formed in a matrix arrangement on a transparent substrate 61 such as glass as a light-transmitting first substrate. At this time, the thin film transistor devices 62 are formed at a pitch much smaller than the pitch of pixels as liquid crystal. In other words, the pitch can be enlarged at the time of transfer, so that the thin film transistor devices 62 themselves can be formed in a high density.

[0040]

The structure of the thin film transistor device 62 is shown in an enlarged view at the right side of FIG. 15, in which a gate electrode layer 62g is provided on a semiconductor thin film 62a of recrystallized silicon or the like through a gate insulation film, and the semiconductor thin film 62a is formed on an insulation region 60 constituted, for example, of silicon oxide film or the like. The semiconductor thin film 62a and the gate electrode layer 62g are covered with an inter-layer insulation film 62i, and the inter-layer insulation film 62i on source-drain regions 62sd, 62sd formed in the semiconductor thin film 62a is opened, where a wiring electrode 62e is formed. A release film 59 for causing

laser ablation upon irradiation with laser is provided on the lower side of the insulation region 60.

[0041]

The thin film transistor device 62 is a device disposed for each pixel of an active matrix type liquid crystal display device as will be described later, and is formed on a second substrate consisting of a transparent material such as glass and plastic so as to be spaced from the first substrate. It is to be noted that in the stage of FIG. 15, desired transistor regions have been formed but final wiring is not yet applied. The thin film transistor devices 62 in the matrix arrangement are disposed on the transparent substrate 61 in the state of being individually separated. The individual separation of the thin film transistor devices 62 can be achieved, for example, by RIE (reactive ion etching) or the like.

[0042]

A device holding substrate 64 for temporarily holding the thin film transistor devices 62 is prepared, and a device holding layer 63 is provided on the surface of the device holding substrate 64 faced to the transparent substrate 61. The device holding substrate 64 is a substrate having a desired stiffness, and may be one of various substrates such as a semiconductor substrate,

a quartz glass substrate, a glass substrate, a plastic substrate and a metallic substrate. The device holding substrate 64 need not specially transmit light such as laser light, so that it need not be formed of a light-transmitting material. The device holding layer 63 is an adhesive layer for temporarily adhering to the surface of the thin film transistor devices 62 and holding the thin film transistor devices 62. The device holding layer 63 can be formed of a thermoplastic resin, a thermosetting resin or the like, and particularly, a silicone resin is preferably used. The silicone resin does not suffer ablation even upon irradiation with excimer laser or YAG laser light, and only the devices can be released, so that yield can be enhanced.

[0043]

The device holding substrate 64 provided with the device holding layer 63 on its surface is faced to the major surface of the transparent substrate 61, and the plurality of thin film transistor devices 62 are press adhered to the surface of the device holding layer 63 at a desired pressure. As shown in FIG. 15, selective irradiation with laser light such as excimer laser and YAG laser is conducted, to cause laser ablation at the interface between the thin film transistor devices 62 as

objects of selection and the transparent substrate 61. By the laser ablation, a gas is generated in the release layer 59 formed at a bottom portion of the thin film transistor devices 62, between the thin film transistor devices 62 as objects of selection and the transparent substrate 61. Therefore, the thin film transistor devices 62 can be released comparatively easily. As the laser light for irradiation, excimer laser is preferably used particularly in view of high output in short wavelength regions, whereby instantaneous processing can be achieved. The laser light is caused to selectively irradiate the thin film transistor devices 62 as objects of selection. For the selective irradiation, a mask provided with desired opening portions may be used, and scanning with controlled irradiation and non-irradiation may also be used. As the release film 59, a film according to the characteristics of the laser used for selective irradiation can be selected; for example, an amorphous silicon thin film, a nitride film or the like can be used.

[0044]

FIG. 16 shows the condition where the thin film transistor devices 62 have been selectively released by laser ablation, in which the thin film transistor devices 62 as objects of selection are adhered to the surface 63a

of the device holding layer 63 and are held on the side of the device holding substrate 64. By such a selective release, the device pitch on the first substrate can be enlarged. The spacing of the thin film transistor devices 62 as objects of selection can be set equal to the spacing of liquid crystal display devices, so that the thin film transistor devices 62 formed in a high density can be spaced apart on a substrate for actual mounting.

[0045]

After desired cleaning and the like are performed, as shown in FIG. 17, a second substrate 68 provided with an adhesive layer 69 on its major surface is prepared. The second substrate 68 is formed of a light-transmitting material such as quartz glass, and the adhesive layer 69 may be formed by use of a UV-curable adhesive, a thermosetting adhesive, a thermoplastic adhesive or the like. The second substrate 68 provided with the adhesive layer 19 on its major surface is mated with the device holding substrate 64 with the thin film transistor devices 62 held thereon, and irradiation with laser light is conducted, whereby the thin film transistor devices 62 on the device holding substrate 64 are transferred onto the second substrate 68. Where the adhesive layer 69 is formed of a UV-curable adhesive, irradiation with UV

light as energy light causes curing of the adhesive layer 69. Therefore, by bringing uncured regions 69y of the adhesive layer 69 into contact with the thin film transistor devices 62 and then irradiating with UV light, the thin film transistor devices 62 can be securely adhered. Where the adhesive layer 69 is formed of a thermosetting adhesive or a thermoplastic adhesive, irradiation with infrared laser light causes adhesion through setting or re-melting. The adhesion of the thin film transistor devices 62 may be achieved through the setting or re-melting of only the regions corresponding to the thin film transistor devices 62, and the adhesion of the thin film transistor devices 62 may be achieved through the setting or re-melting of the entire surface of the adhesive layer 69. Where a silicone resin is used as the device holding layer 63, particularly, even when the adhesive layer 69 and the device holding layer 63 make contact with each other, the excellent release property ensures that the device holding substrate 64 can be easily released.

[0046]

Next, as shown in FIG. 18, the device holding substrate 64 is removed together with the device holding layer 63, to yield the second substrate 68 onto which the

thin film transistor devices 62 have been selectively transferred. At this stage, the thin film transistor devices 62 are arranged at positions conforming to the pixel pitch of the liquid crystal display device.

[0047]

After the thin film transistor devices 62 are transferred onto the second substrate 68 in accordance with the pixel pitch, as shown in FIG. 19, an inter-layer insulation film 70 is provided on the thin film transistor devices 62, then the inter-layer insulation film 70 is provided with desired window portions and wiring portions, thereafter pixel electrodes 71 constituted of transparent ITO or the like are provided for each pixel, and an oriented film 72 is provided thereon. In parallel to this, a common electrode 75 constituted of ITO film or the like is provided on a transparent counter substrate 76, and an oriented film 74 is provided thereon. Finally, the second substrate 68 and the transparent counter substrate 76 are faced to each other with a desired spacing therebetween, and a liquid crystal 73 is injected between the second substrate 68 and the transparent counter substrate 76, to complete the liquid crystal display device.

[0048]

In the method of transferring device as described above, the energy beam for release of devices is caused to selectively irradiate the interface between the thin film transistor devices 62 and the first substrate, so that release at the interface between the devices and the substrate is achieved by laser ablation in a short time, and the devices and the like are not damaged. In addition, the thin film transistor devices 62 are flat plate shaped, and are securely adhered to the device holding layer 63 constituted, for example, of a silicone resin or the like, and are transferred without positional stagger. Therefore, the liquid crystal display device can be produced while restraining the lowering of yield of production. Since the thin film transistor devices 62 are formed in a high density on the first substrate, a reduction in cost can be achieved through mass production. Besides, the thin film transistor devices 62 are selectively transferred in accordance with the pixel pitch, so that an increase in screen size of the liquid crystal display device can be easily achieved.

[0049]

[Effects of the Invention]

As has been described above, in the method of transferring device according to the present invention,

the energy beam for release of devices is caused to selectively irradiate the interface between the devices and the first substrate, so that release at the interface between the devices and the substrate is achieved by laser ablation in a short time, without damage to the devices or the like. The interface between the devices and the substrate is not specially formed but is formed spontaneously in the process of forming the devices, so that formation of a release thin film for the purpose of release is not needed, and the increase in the number of steps can be minimized.

[0050]

In addition, where the light-emitting diodes as the devices have pointed head portions, the device holding layer is provided with recessed portions for fitting of the pointed head portions, so that the light-emitting diodes are securely adhered to the device holding layer, and are transferred without positional stagger. Therefore, the image display device or the like can be produced while restraining the lowering of yield of production. Besides, even where the light-emitting diodes as the devices or the thin film transistor devices of the liquid crystal display device are flat plate shaped, the light-emitting diodes or the thin film transistor devices are

securely adhered to the device holding layer in the same manner as above, and are transferred without positional stagger.

[0051]

In addition, in the device holding substrate and the method of producing the same according to the present invention, the device holding layer provided with recessed portions for fitting of the pointed head portions of the devices can be securely formed, and can be applied to the above-described method of transferring device, whereby transfer can be achieved in a short time without causing an increase in the number of steps.

[Brief Description of the Drawings]

[FIG. 1]

FIG. 1 is a step sectional view showing the step of irradiating with laser light in a method of transferring device according to First Embodiment of the present invention.

[FIG. 2]

FIG. 2 is a step sectional view showing the step of transferring light-emitting diodes in the method of transferring device according to First Embodiment of the present invention.

[FIG. 3]

FIG. 3 is a step sectional view showing the step of cleaning the light-emitting diodes in the method of transferring device according to First Embodiment of the present invention.

[FIG. 4]

FIG. 4 is a step sectional view showing the step of transferring the light-emitting diodes onto a second substrate in the method of transferring device according to First Embodiment of the present invention.

[FIG. 5]

FIG. 5 is a step sectional view showing the condition after the transfer of the light-emitting diodes onto the second substrate in the method of transferring device according to First Embodiment of the present invention.

[FIG. 6]

FIG. 6 is (a) a sectional view and (b) a plan view showing an example of light-emitting device used in the method of transferring device according to Embodiment of the present invention.

[FIG. 7]

FIG. 7 is a step sectional view showing the step of irradiating with laser light in a method of transferring

device according to Second Embodiment of the present invention.

[FIG. 8]

FIG. 8 is a step sectional view showing the step of transferring light-emitting diodes in the method of transferring device according to Second Embodiment of the present invention.

[FIG. 9]

FIG. 9 is a step sectional view showing the step of cleaning the light-emitting diodes in the method of transferring device according to Second Embodiment of the present invention.

[FIG. 10]

FIG. 10 is a step sectional view showing the step of transferring the light-emitting diodes onto a second substrate in the method of transferring device according to Second Embodiment of the present invention.

[FIG. 11]

FIG. 11 is a step sectional view showing the condition after the transfer of the light-emitting diodes onto the second substrate in the method of transferring device according to Second Embodiment of the present invention.

[FIG. 12]

FIG. 12 is a step sectional view showing the step of forming a release layer in a method of producing a device holding substrate according to Third Embodiment of the present invention.

[FIG. 13]

FIG. 13 is a step sectional view showing the step of forming a silicone resin layer in the method of producing the device holding substrate according to Third Embodiment of the present invention.

[FIG. 14]

FIG. 14 is a step sectional view showing the step of releasing the device holding substrate in the method of producing the device holding substrate according to Third Embodiment of the present invention.

[FIG. 15]

FIG. 15 is a step sectional view showing the step of irradiating with laser light in a method of transferring device according to Fourth Embodiment of the present invention.

[FIG. 16]

FIG. 16 is a step sectional view showing the step of releasing thin-film transistor devices in the method of transferring device according to Fourth Embodiment of the present invention.

[FIG. 17]

FIG. 17 is a step sectional view showing the step of adhering the thin-film transistor devices in the method of transferring device according to Fourth Embodiment of the present invention.

[FIG. 18]

FIG. 18 is a step sectional view showing the step of transferring the thin-film transistor devices onto a second substrate in the method of transferring device according to Fourth Embodiment of the present invention.

[FIG. 19]

FIG. 19 is a step sectional view showing the step of assembling a liquid crystal display device in the method of transferring device according to Fourth Embodiment of the present invention.

[Description of Reference Numerals]

10, 40: sapphire substrate

12, 42: light-emitting diode

13: device holding layer

14, 44: device holding substrate

15, 45: laser light

16f, 46f: cleaning liquid

18, 48: second substrate

19, 49: adhesive layer

43: silicone resin layer

42a: pointed head portion

43b: recessed portion

[Name of Document] Abstract of the Disclosure

[Abstract]

[Object] To provide method of transferring device, method of producing device holding substrate, and device holding substrate, which enable devices to be transferred in a short time without inducing an increase the number of steps and without lowering of the yield of transfer.

[Solving Means] The interface between a first substrate 10 and light-emitting diodes 12 formed on the first substrate 10 is irradiated with an energy beam selectively and transmitting through the first substrate 10, thereby selectively releasing the light-emitting diodes 12, then the light-emitting diodes 12 are transferred onto a device holding layer 13 formed on a device holding substrate, and thereafter the light-emitting diodes 12 are transferred onto a second substrate 18. By the irradiation of the interface with the energy beam, the devices can be easily released.

[Selected Drawing] FIG. 1

In the drawings:

[FIG. 1]

10: sapphire substrate

12: light-emitting diode

13: device holding layer

14: device holding substrate

[FIG. 2]

13a: surface

[FIG. 3]

16: cleaning tank

16f: cleaning liquid

[FIG. 4]

18: second substrate

19: adhesive layer

[FIG. 6(a)]

31: ground growth layer

32: GaN layer

33: InGaN layer

34: GaN layer

35: p electrode

36: n electrode

[FIG. 7]

40: sapphire substrate

42: light-emitting diode

42a: pointed head portion

43: silicone resin layer

43b: recessed portion

44: device holding substrate

45: laser light

A: first substrate

[FIG. 9]

46: cleaning tank

46f: cleaning liquid

[FIG. 10]

47: energy light

48: second substrate

49: adhesive layer

[FIG. 12]

50: sapphire substrate

52: light-emitting diode

53: release layer

[FIG. 13]

54: silicone resin layer

55: device holding substrate

[FIG. 14]

52a: pointed head portion

54b: recessed portion

[FIG. 15]

59: release film

61: transparent substrate

62: TFT device

63: device holding layer

64: device holding substrate

[FIG. 17]

68: second substrate

69: adhesive layer

[FIG. 19]

62: TFT device

71: pixel electrode

73: liquid crystal

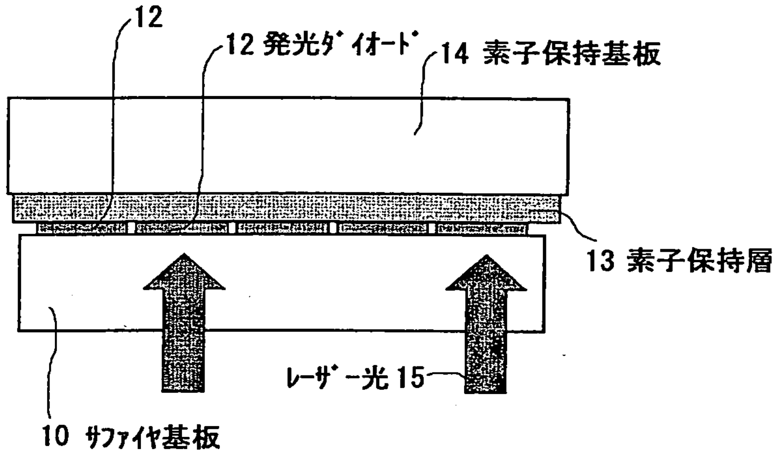
74: oriented film

75: common electrode

76: transparent counter substrate

【書類名】　図面

【図１】



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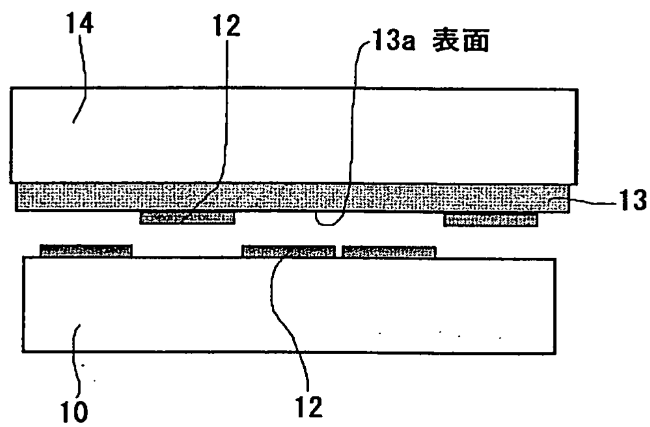

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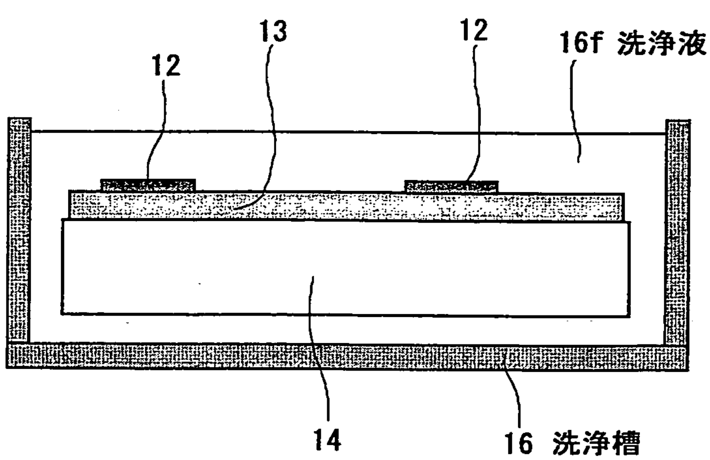

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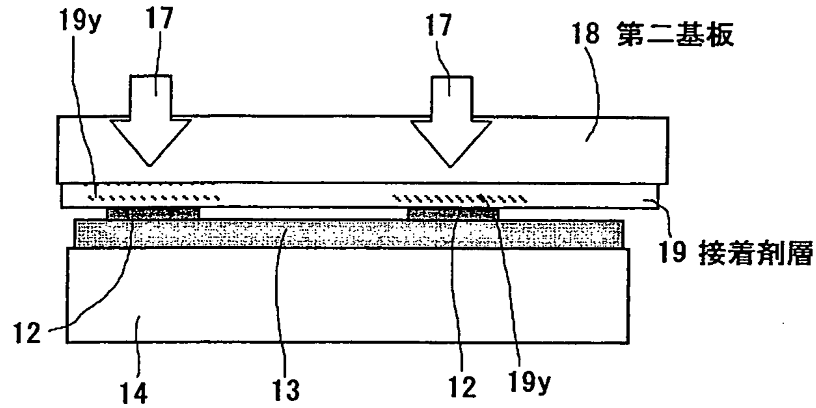

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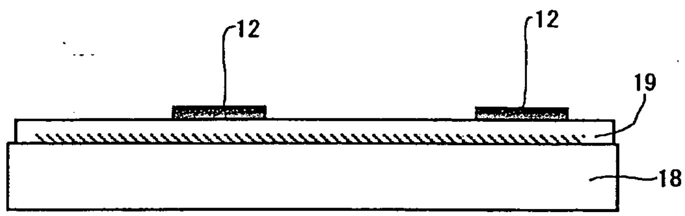

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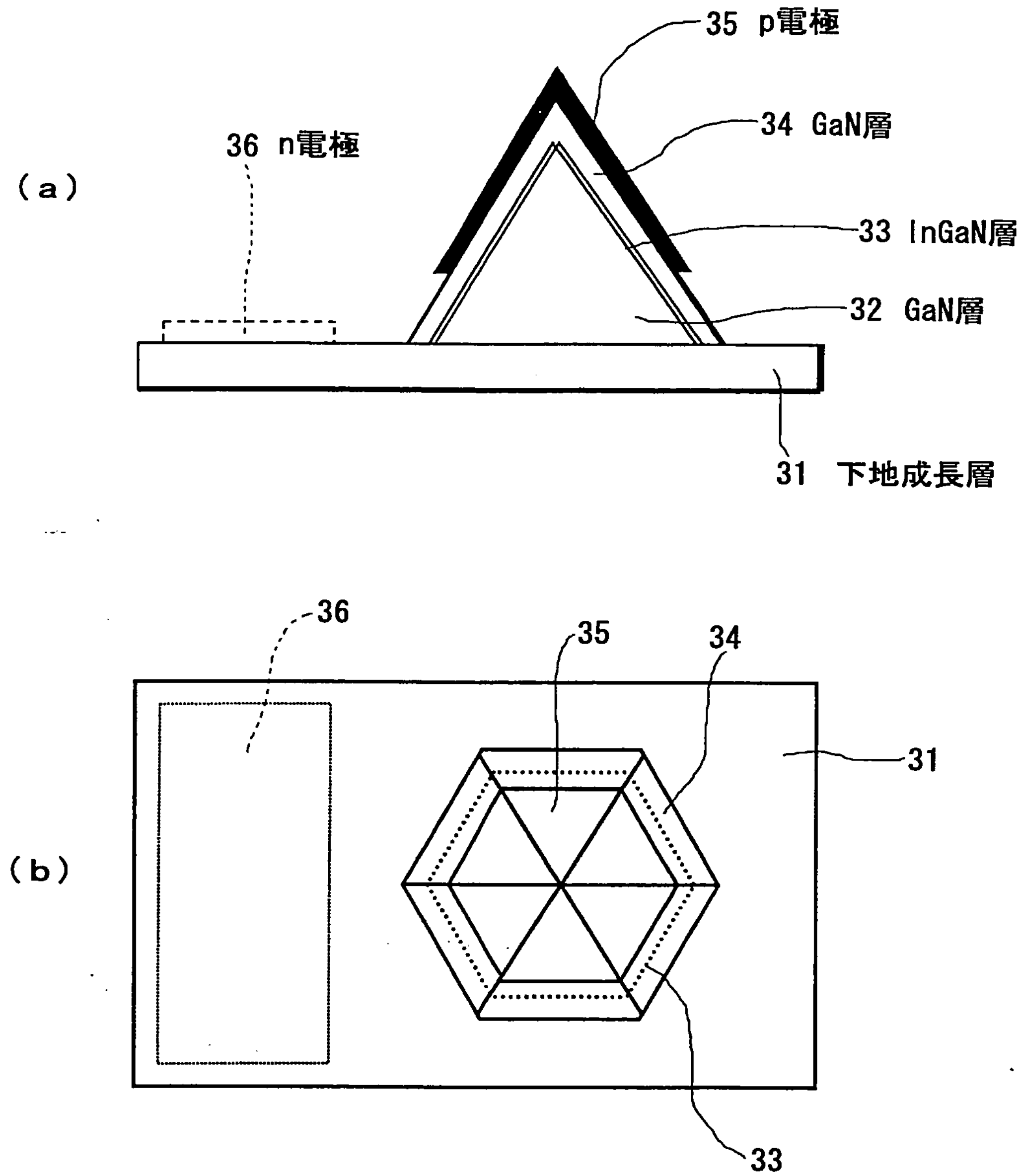

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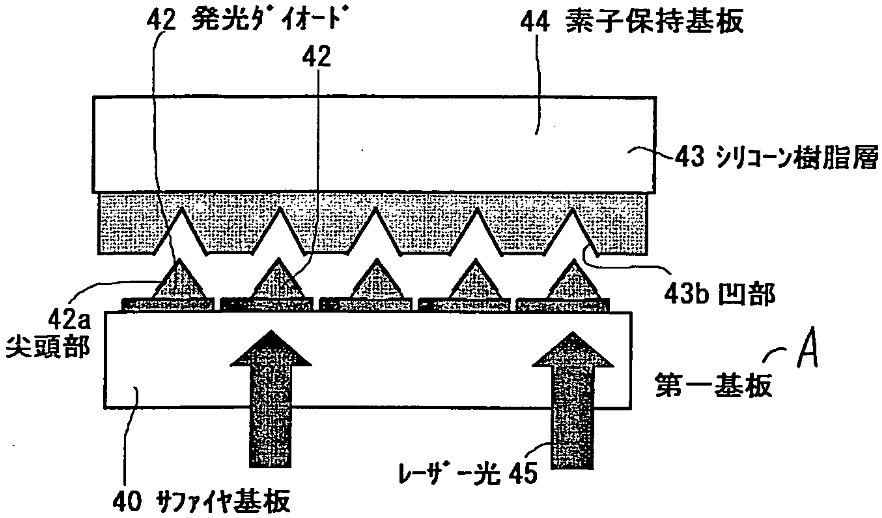
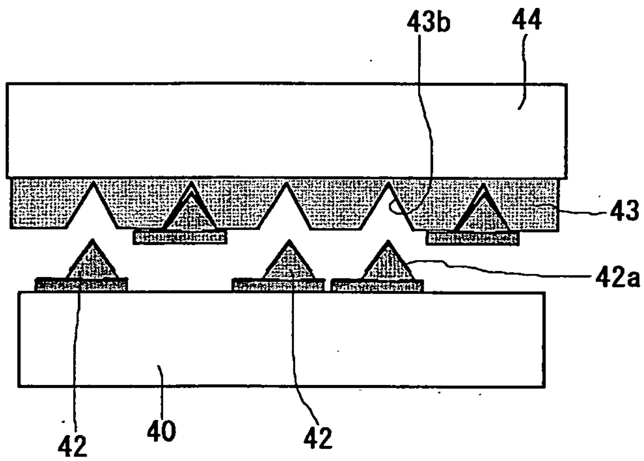

42 発光ﾀﾞｲｵｰﾄﾞ
44 素子保持基板
42
43 ｼﾘｺｰﾝ樹脂層
43b 凹部
42a
尖頭部
A
第一基板
レーザ゛ー光 45
40 ｻﾌｧｲﾔ基板

【図８】


43b
44
43
42a
42
40
42

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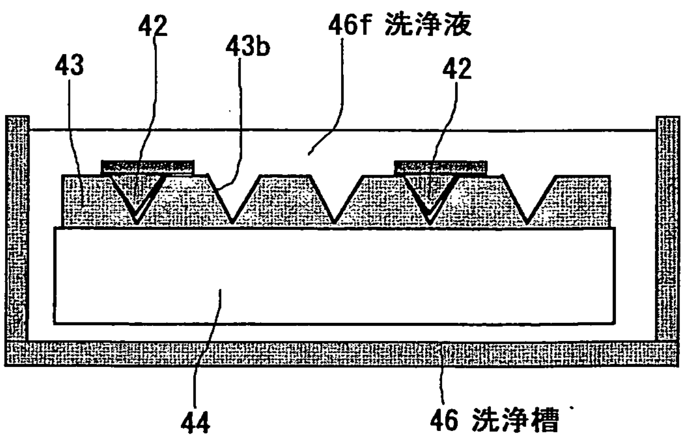
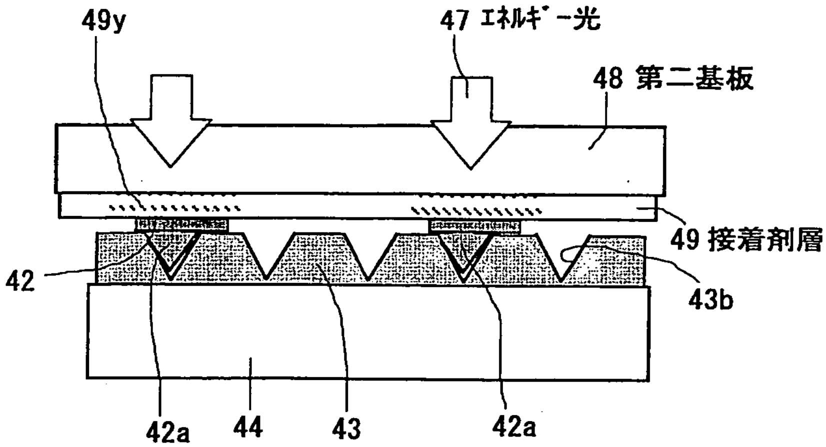
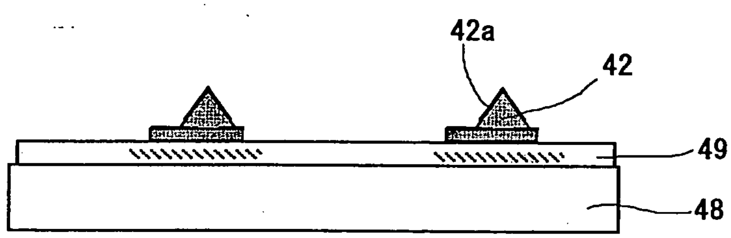

42
43b
46f 洗浄液
43
42
44
46 洗浄槽

【図１０】


49y
47 ｴﾈﾙｷﾞｰ光
48 第二基板
49 接着剤層
42
43b
42a
44
43
42a

【図１１】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49
48

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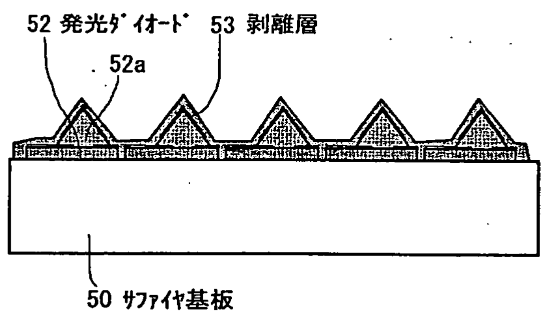
52 発光ﾀﾞｲｵｰﾄﾞ
53 剥離層
52a
50 ｻﾌｧｲﾔ基板

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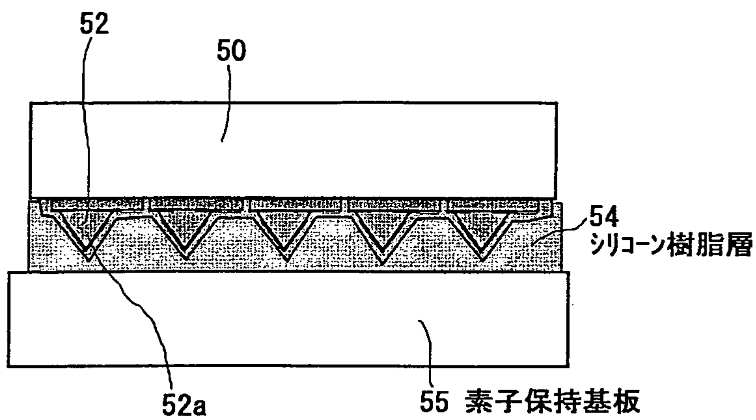
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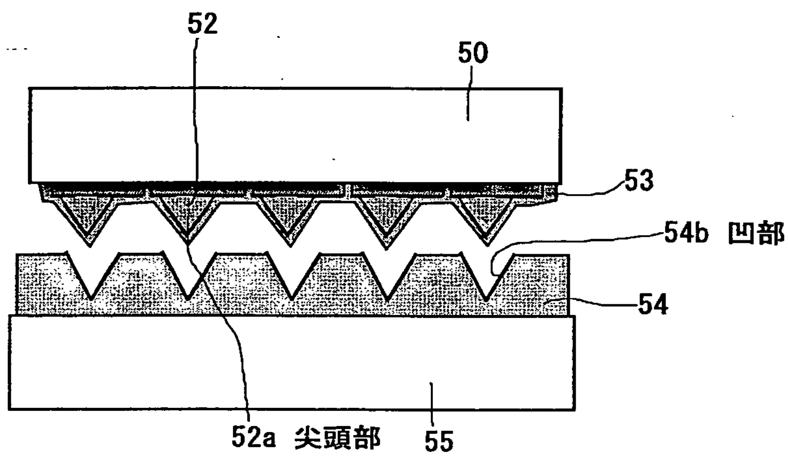
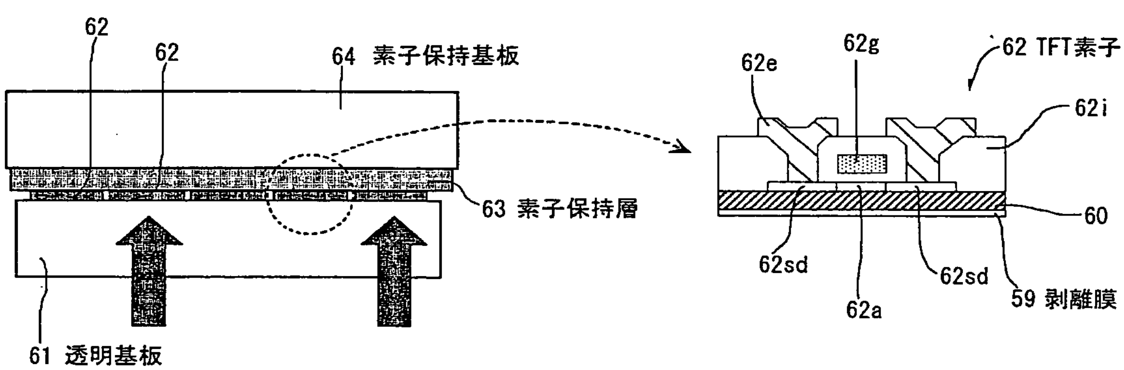
50
54
シリコーン樹脂層
52a
55 素子保持基板

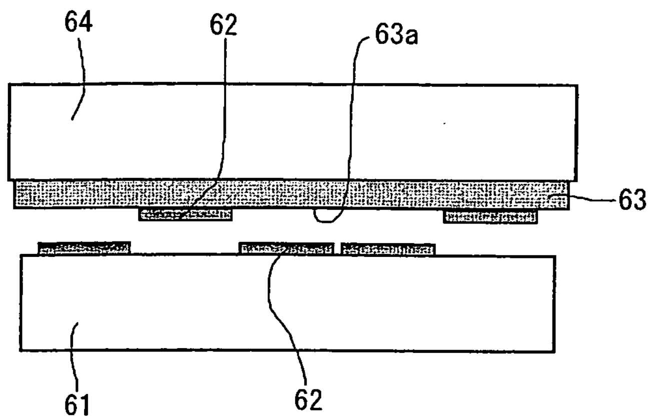
【図１４】


52
50
53
54b 凹部
54
52a 尖頭部
55

【図１５】


62
62
64 素子保持基板
63 素子保持層
61 透明基板
62e
62g
62 TFT素子
62i
60
62sd
62sd
62a
59 剥離膜

【図１６】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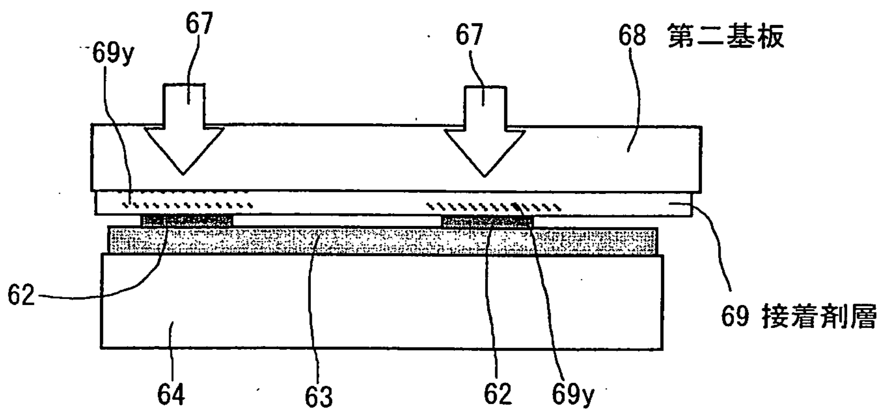
62
63a
63
61
62

【図１７】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69y
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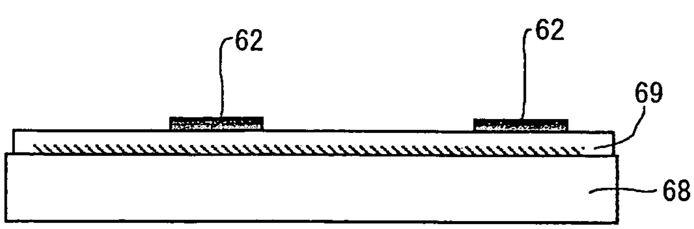
69 接着剤層
64
63
62
69y

【図１８】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【図１９】